

# Pathfinder Innovation Challenge

## *Participants Guide*

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November 17, 2009

*Welcome to the Pathfinder Innovation Challenge!* This guide describes the four Leagues in detail and how to get started in each. Before continuing, you should make sure that you carefully read and accept the Official Contest Rules on the Contest Website at <http://mars.jpl.nasa.gov/beamartian/pic>.

There are four Leagues in the Pathfinder Innovation Challenge that are designed with different age ranges and skills in mind. The **Inspiration League** invites Entrants 14 years and older to develop an episode for “The Martians” video series. Join the **Scholarship League** if you're over 14 and would like to build a compelling and exciting interactive web application for students and the rest of the world to learn about rocks on Earth and Mars. Entrants over age 18 in the **Global Cooperation League** will develop fun web games that crowd-source the task of finding and labeling interesting objects in an enormous set of images acquired by the Mars rovers. The **Intelligence League** challenges Entrants over age 18 to accomplish the same task with autonomous applications that can rapidly detect and label these interesting objects.

**IMPORTANT:** Appendices to this document will be provided on the Contest Website with new and updated information as the contest progresses.

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## The Inspiration League

Want to be a "Virtual Citizen of Mars" and teach others here on Earth about the Red Planet and your interest in it? The Inspiration League encourages non-software developers to use their computer, video camera, and communications skills by creating an episode for "The Martians" video series. Submissions should share personal and local enthusiasm for Mars exploration, missions, and/or comparisons between Earth and Mars, making sure content is accurate so that viewers can learn from your Submission. You'll also want to make sure that anything you submit is your own original work and does not contain copyrighted material (including music). Check the Official Contest Rules for details.

### How to Compete in the Inspiration League

Entrants in the Inspiration League will produce a movie designed for online viewing, edited to be no longer than 4 minutes in duration. The final version of the movie must be saved on a DVD. Please refer to the Official Contest Rules for all of the items that must be included with the DVD and the address for Submission. All forms related to the Submission will be found on the Contest Website.

The final score for each movie will be computed as follows:

Weight	Component	Description
50%	Accuracy	How accurate the Mars-related content is
20%	Creativity	How clever or novel the approach is
15%	Elegance	How well the video was made
15%	Complexity	How difficult the editing and/or other techniques are

## The Scholarship League

The goal of the Scholarship League is to create an interactive and engaging web-based interface to teach K-12 students and life-long learners about rocks on Earth and Mars, while encouraging the public to help scientists collect Earth rocks that can be compared to rocks found on Mars. The challenge is to create an interactive for the Rock Around the World project: <http://ratw.asu.edu/> that repackages content on the site in order to present submitted rocks in a more seamless fashion, and to teach people about rocks and minerals, the rock cycle, and rock spectra. It should include a mapping function showing where Earth rocks came from and a learning interactive, similar to that created for atmospheres at [http://lasp.colorado.edu/education/spectra/goldilocks\\_interactive/](http://lasp.colorado.edu/education/spectra/goldilocks_interactive/) but that allows people to compare rocks and spectra instead.

The application should be designed to address and reinforce the following National Science Education Standards:

Grades K-4 Content Area: Physical Sciences	
Standard	Guide to the Standard
Understanding of properties of objects and materials	Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with other substances. Those properties can be measured using tools, such as rulers, balances, and thermometers [and in the case of the Rock Around the World Project, spectrometers].
Grades 5-8 Content Area: Earth & Space Sciences	
Standard	Guide to the Standard
Understanding the structure of the earth system	Some changes in the solid earth can be described as the "rock cycle." Old rocks at the earth's surface weather, forming sediments that are buried, then compacted, heated, and often recrystallized into new rock. Eventually, those new rocks may be brought to the surface by the forces that drive plate motions, and the rock cycle continues.
Grades 5-8 Content Area: History & Nature of Science	
Standard	Guide to the Standard
Understanding of science as a human endeavor	Women and men of various social and ethnic backgrounds--and with diverse interests, talents, qualities, and motivations--engage in the activities of science, engineering, and related fields such as the health professions. Some scientists work in teams, and some work alone, but all communicate extensively with others.
	Science requires different abilities, depending on such factors as the field of study and type of inquiry. Science is very much a human endeavor, and the work of science relies on basic human qualities, such as reasoning, insight, energy, skill, and creativity--as well as on scientific habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.

## How to Compete in the Scholarship League

Entrants in this League must develop an interactive, web-based experience that engages users, while educating them. We must be able to host your application on the Windows Azure Platform, and it must work within Silverlight 3. Further, each interactive should function in Internet Explorer 8, Safari 4, and Firefox 3 on the major consumer operating systems: Windows (XP SP2+, Vista, 7) and Mac OSX (10.5+).

Final submissions must be made by 11:59:59 am PT on February 15, 2009. Each Submission should include source code and the other items listed in the Official Contest Rules. We may choose to post your application to gather ratings from the general public and use those ratings in final judging.

The final score for each application will be computed as follows:

Weight	Component	Description
30%	Educational Relevance	How well it meets educational goals
25%	User Experience	How enjoyable and engaging the application is
25%	Elegance	How efficient, well written, and reusable the code is
20%	Comprehensiveness	How many elements of the "Rock Around the World" website are integrated

## Token Hunting in the Global Cooperation and Intelligence Leagues

The Spirit and Opportunity Mars Rovers have acquired hundreds of thousands of images over the past five years -- the largest set of images that we've ever taken from the surface of another planet. In the Global Cooperation and Intelligence Leagues of the Pathfinder Innovation Challenge (each described in more detail later), we are challenging you to help us make this dataset even better.

NASA's Jet Propulsion Laboratory has taken the first step by making all of the Mars rover images available to you via the Windows Azure platform. We are also releasing the complete metadata for all of these images for you to use in your applications. Now it's your turn to build programs that access, analyze, and annotate these images.

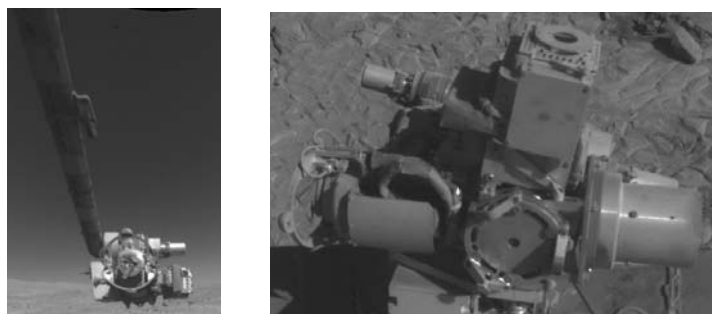
Both the Global Cooperation League and the Intelligence League, described in more detail below, seek to find interesting things on Mars that we're calling *tokens*. Tokens are items of interest, such as the rover arm, a crater rim, or other features in a Mars image. Mission scientists and engineers often have to search through hundreds of images trying to find these tokens in order to test a hypothesis about Mars or about how the rovers are functioning. Sometimes it's like searching for a needle in a haystack! If your application can find most of these tokens for them, it will help them accomplish more with the rovers and make the dataset more useful for everyone.

Here are the tokens we're trying to find:

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### Rover Arm (Token ID: A)

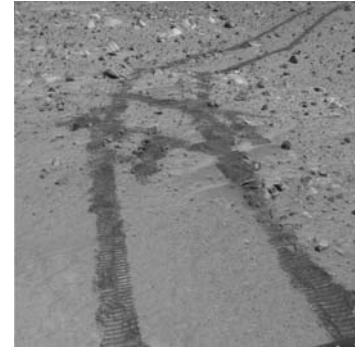
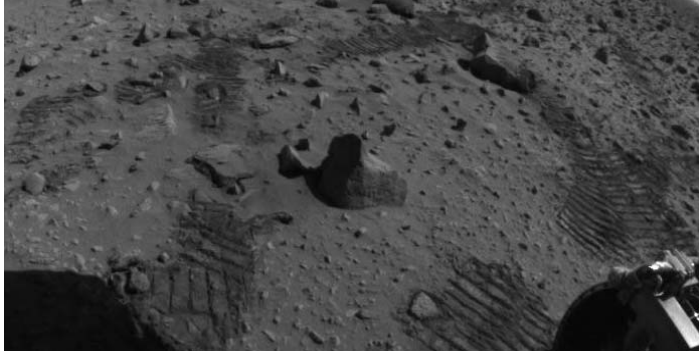
Images that contain any part of the rover arm when it is deployed, that is, extended from its stowed position on the rover body.



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### Rover Tracks (Token ID: T)

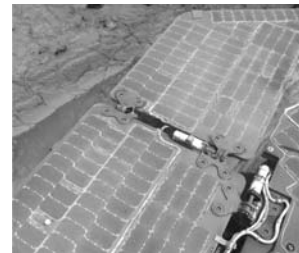
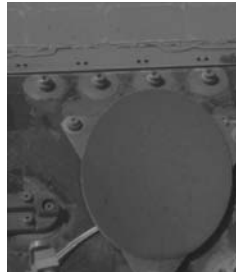
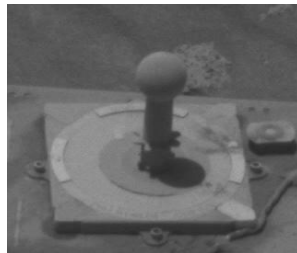
Images of soil displaced by the rover wheels. Some images may only show tracks from one of the wheels or even multiple sets of tracks from the rover.




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### Rover Deck (Token ID: D)

Images that contain any part of the deck of the rover or any part of the rover that is mounted on the deck, such as calibration target, UHF antenna, high-gain antenna, camera mast, solar cells, etc.




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### All Sky (Token ID: Y)

Images that only contain sky (possibly with the Sun, a moon, or other celestial object) and no terrain.




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### Horizon (Token ID: H)

Images that contain both sky and terrain.



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## Crater Rim (Token ID: C)

For a given crater, images that contain some terrain that is located both

- 1) outside the crater and
- 2) inside the crater



Note that we're not looking for pictures of *just any* crater on Mars. Below is a list of the specific craters that we're interested in:

### Spirit Craters:

- Bonneville
- Missoula
- Lahontan

### Opportunity Craters:

- Eagle
- Fram
- Endurance
- Victoria
- Beagle

Additional information on these craters is available at the links below:

[http://en.wikipedia.org/wiki/List\\_of\\_surface\\_features\\_of\\_Mars\\_seen\\_by\\_the\\_Opportunity\\_rover#Craters](http://en.wikipedia.org/wiki/List_of_surface_features_of_Mars_seen_by_the_Opportunity_rover#Craters)

[http://en.wikipedia.org/wiki/List\\_of\\_surface\\_features\\_of\\_Mars\\_seen\\_by\\_the\\_Spirit\\_rover#Craters](http://en.wikipedia.org/wiki/List_of_surface_features_of_Mars_seen_by_the_Spirit_rover#Craters)

[http://en.wikipedia.org/wiki/Spirit\\_rover#Missoula\\_and\\_Lahontan\\_Craters.2C\\_en\\_route\\_to\\_Columbia\\_Hills](http://en.wikipedia.org/wiki/Spirit_rover#Missoula_and_Lahontan_Craters.2C_en_route_to_Columbia_Hills)

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## Shadows (Token ID: S)

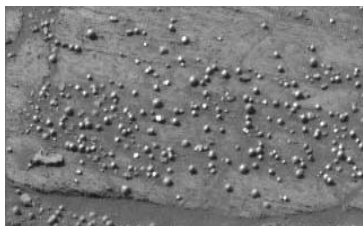
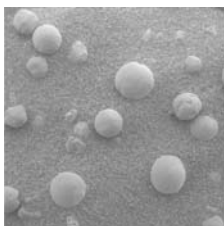
Images that contain an area in shadow on the terrain (rock, soil, etc.) that is caused either caused by occlusion from the rover, or the terrain itself such from a rock onto the adjacent soil, a rock shadowing itself, or a crater wall onto the adjacent terrain beneath it. To qualify, an image must contain a contiguous region of pixels in shadow that is at least 2% of the image area in size. The region of pixels is defined as 4-connected, meaning that all pixels in the region must have at least one neighbor that is connected on top, bottom, left or right (diagonals do not count).



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### Blueberries (Token ID: B) (Opportunity Images only)

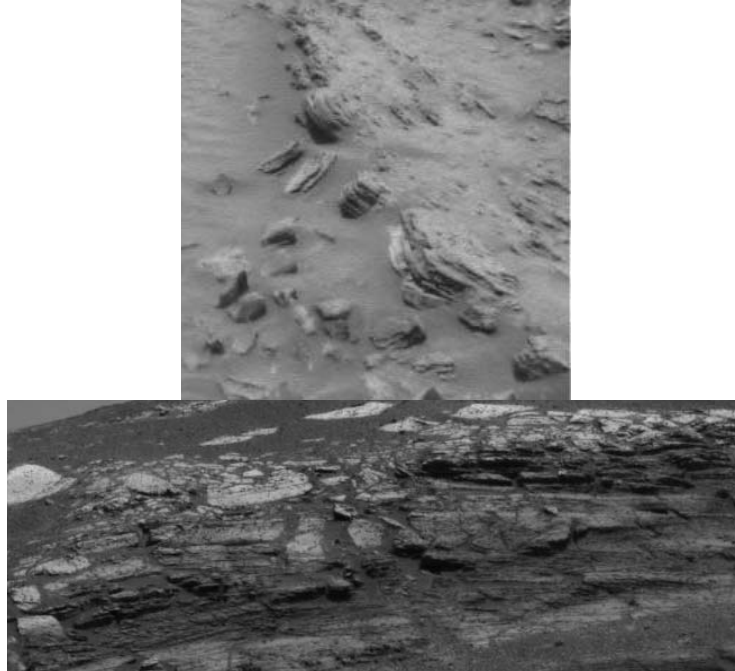
These nearly spherical features are found on Meridiani Planum embedded in a rock or laying on soil. They are nearly spherical concretions consisting mainly of hematite and were formed in the presence of water. Most of them are individual spherules that are between 0.25 to 7 mm in size. Rarely 2 or 3 may be connected to each other. An image must show part or all of at least one blueberry of 8 pixels in size or more to qualify.



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### Layering (Token ID: L)

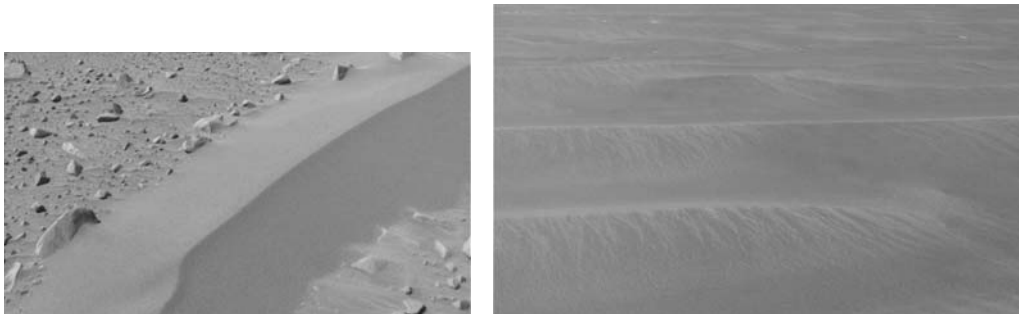
Layering is a feature that may be observed on certain rocks and on the stratified walls of craters. It appears as a series of roughly parallel linear or slightly sinuous layers of material on a rock or exposed strata such as on a crater wall. There are many examples of layering in the Home Plate area of Gusev Crater, in numerous rocks found at Meridiani Planum, and in some crater walls of sufficient depth. Images must show part or all of at least one layered rock or crater wall to qualify.



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### **Sand Ripples (Token ID: R)**

Sand ripples are long mounds of wind-blown granular material. Each mound has a crest that is straight or slightly sinuous, sloping sides and is longer than it is high. An image must show part or all of at least one ripple crest having a length of at least 20% of the width of the image to qualify.



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Please see Appendix A for examples of images that contain the tokens described above. The Global Cooperation League and the Intelligence League challenge you to find these tokens in two very different ways. Read on to learn about the rules for each.

### **Answer Sets**

Global Cooperation and Intelligence League Entrants will have access to over two hundred thousand rover images via Windows Azure. In each League, Entrants must write an application that can load the images, analyze each image (either by using computer intelligence in the Intelligence League, or through

“crowd sourcing” in the Global Cooperation League), and save an “answer set” that appends token IDs to each image, separated by commas. Each token ID must be preceded by a plus (+) or minus (-) to indicate whether that token is present or not in the image. Here is an example of how an answer set should be formatted:

```
2F126468064RSD0000P1001L0MZ,+R,-C,-D
2F126468064RSD0000P1001R0MZ,+H,+T
2F126715028RSD0200P1003L0MZ,-R,-T
```

Note that the above is only an example - these aren't correct answers! In this answer set, the competitor's application is stating that the first image contains sand ripples (R), but does not contain any craters (C) or the rover deck (D). The second line claims that the specified image contains the horizon (H) and rover tracks (T). The third line indicates that the image in question does not contain sand ripples or rover tracks. Note that your answer set does not have to include every possible token, but for each token included it must include a plus or minus to indicate whether the token is present or not present, respectively. An answer set must conform *exactly* to the format specified above or it will not be scored. Any invalid image IDs or token IDs will also cause an entry to be rejected.

Answer sets are scored as follows:

```
Correctly indicated token: +1 point
Incorrectly indicated token: -1 point
Omitted token: 0 points
```

## The Global Cooperation League

Think that people can out-compute machines? Prove it! The goal of the Global Cooperation League is to build compelling games that will entice players to discover the tokens described in the “Token Hunting” section above. These games leverage the power of large crowds working together to find the tokens in the rover images.

### How to Compete in the Global Cooperation League

Players in this League must develop a unique gaming experience using JPL's released Mars image data. The object of the game must be to discover which images contain the tokens described above. Entrants must have an approach to thwart any malicious attempts or erroneous responses that may add noise to their dataset.

A successful entry in this League will be (a) engaging, (b) replayable, and (c) use elegant crowd-sourcing techniques to maximize the utility of the collected data. We must be able to host your entries on Windows Azure Platform. Further, each game should function in Internet Explorer 8, Safari 4, and Firefox 3 in the major

consumer operating systems: Windows (XP SP2+, Vista, 7) and Mac OSX (10.5+).

Games may choose to present images from the full image dataset or a subset to users in any order desired. As the game is played, two “answer set” files must be produced, as described in the “Token Hunting” section above. The first file produced by the game is a “raw answer set” containing one line for each attempt made by a user to indicate the presence or absence of one or more tokens in the indicated image. It is expected that this file will have many duplicate entries.

The games must also produce a “distilled answer set” that contains no more than one line per image identifier. The tokens that follow each line identifier should represent an entrant’s best guess of what tokens are present in each image on the basis of combining all of the opinions gathered by players of the game. Scoring is only performed on the distilled answer set.

### Scoring

The scoring in Semi-final and Final rounds for each application will be computed as follows:

Weight	Component	Description
30%	Accuracy	How high a score is achieved from the submitted distilled answer set
25%	User Experience	How enjoyable and engaging the game is
25%	Elegance	How efficient, well written, and reusable the code is
20%	Creativity	How inventive and “out of the box” the approach to the problem is

### Semi-Finals

The Global Cooperation League competition occurs in two phases. The first phase begins at the start of the Contest and ends when Entrants submit their system to qualify for the League Semi-finals. The second phase begins with the announcement of the Semi-finalists and ends when Entrants selected as Semi-finalists submit their final systems for judging.

To qualify for the Semi-finals, we must receive your entry by February 15<sup>th</sup>, 2010 (11:59:59 am PT). Each submission should include all source code, instructions on running the program, and a detailed document describing the game, and other elements described in the rules document. The submission package should contain screenshots and 1-2 paragraphs highlighting key features of the game. Entries must be self-contained and access only data files on the local disk and the JPL-released rover images. We will announce up to 15 Semi-finalists at MIX10 on or about March 15<sup>th</sup>, 2010.

### Finals

The Semi-finalists will receive feedback after MIX10, and throughout the Finals phase of the competition. The Semi-finalists will have until April 16<sup>th</sup>, 2010 to

improve their games. The games submitted by Semi-finalists will be posted on the Contest Website, where it will be made available to the general public to play against all of the images provided by JPL. We may collect various statistics during this period to assess the popularity of each game.

By 11:59:59 am PT on April 16<sup>th</sup>, 2010, each Semi-finalist must submit his or her final submission including source code, a detailed write up, the raw and distilled answer sets, and other items described in the official contest rules.

The winners of the Global Cooperation League will be announced on or about May 18<sup>th</sup>, 2010.

## The Intelligence League

Bring your best AI to this challenge! The goal of the (artificial) Intelligence League is to develop automated and efficient image processing applications to discover the tokens described above.

### How to Compete in the Intelligence League

When the contest begins, we will release several important text files called "trial sets" that will each consist of several thousands of image identifiers, one per line. Nothing else will be in the file. Here's a bit of what a trial set will look like:

```
2F126468064RSD0000P1001L0MZ  
2F126468064RSD0000P1001R0MZ  
2F126715028RSD0200P1003L0MZ
```

Each identifier in a trial set corresponds to one Mars rover image. Intelligence League applications must accept a trial set as input, load the images indicated by the identifiers, and produce an answer set containing the image identifiers along with appropriate token identifiers in the format described above in the "Token Hunting" section.

About a month after the start of the Intelligence League, we will open a public "Leaderboard" for each trial set. Once the leaderboards are open, Entrants can submit one answer set per trial set on each day of the Contest via the Contest Website. Answer sets will be scored automatically and the scores of each entrant's most recent submission will be publicly posted on the corresponding leaderboard. Scoring will be performed by comparing a secret subset of an entrant's answer set to a truth set generated by JPL mission engineers and scientists using the formulas described at the end of the Token Hunting section above.

### Scoring

The score of an Intelligence League application in the Semi-final and Final rounds will be computed as follows:

Weight	Component	Description
30%	Accuracy	How high a qualifying score is achieved on the trial sets
25%	Creativity	How inventive and “out of the box” the approach to the problem is
25%	Elegance	How efficient, well written, and reusable the code is and how well it generalizes to new images
20%	Performance	How fast the application produces correct answers

## Semi-Finals

The Intelligence League competition occurs in two phases. The first phase begins at the start of the contest and ends when Entrants submit their system to qualify for the League Semi-finals. The second phase begins with the announcement of the Semi-finalists and ends when these Entrants submit their final systems for judging.

All Entrants who wish to compete for a spot in the Semi-finals must submit their system for judging no later than February 15<sup>th</sup> at 11:59:59 am PT). This submission must include their application source code, a document describing how their algorithm works, and other elements listed in the Official Contest Rules.

Entries must be entirely autonomous, which means that once started, they must produce a complete answer set without any human interaction. Entries must be self-contained and may only access data on the local disk and the JPL-released rover images in Windows Azure. All entries must be deployable within the Windows Azure environment. Entries must complete execution on each trial data set in less than 24 Windows Azure VM hours and require no more than 50 Gigabytes of local disk storage and 20 Gigabytes of network bandwidth.

Up to 15 Entrants will be selected by the judges to advance. The Semi-finalists will be announced at MIX10 on or about March 15<sup>th</sup>, 2010.

## Finals

The Sponsors will provide feedback to the Semi-finalists at the MIX10 conference, and throughout the Finals round. After receiving the feedback, players will have a month to improve their application before final submission. The final Submission is due on April 16<sup>th</sup>, 2010 at 11:59:59 am PT.

## Working with the Mars Rover Images

This section provides some details on the Mars rover images, their metadata, and how to access them via the Windows Azure Platform. More details will be provided on the Website.

## **File naming convention**

Each Mars rover image has a long filename that contains a lot of information about the image, when it was taken, and where. For details on this filename convention, please refer to this webpage:

[http://marsrovers.jpl.nasa.gov/gallery/edr\\_filename\\_key.html](http://marsrovers.jpl.nasa.gov/gallery/edr_filename_key.html)

## **Working with the Windows Azure Platform**

To support the Pathfinder Innovation Challenge, we are releasing all of the images acquired by the Spirit and Opportunity Mars rovers via the Windows Azure Platform. This section contains links to several webpages that will help competitors in the Scholarship, Global Cooperation, and Intelligence Leagues learn about working with this platform:

Azure Services Platform Training Kit:

<http://www.microsoft.com/downloads/details.aspx?FamilyID=413E88F8-5966-4A83-B309-53B7B77EDF78>

How Do I? Videos:

<http://msdn.microsoft.com/en-us/azure/dd439432.aspx>

OnDemand Webcasts:

<http://www.microsoft.com/events/series/azure.aspx?tab=webcasts&id=odall>

On Demand Video of Sessions from the MIX '09 Conference:

<http://videos.visitmix.com/MIX09/Tags/Azure>

Virtual Labs

<http://www.microsoft.com/events/series/azure.aspx?tab=virtuallabs>

Podcasts

<http://www.microsoft.com/events/series/azure.aspx?tab=podcasts&pageId=x1429&seriesID=Series-d2978faa-58d8-4e63-b5f3-4f13f7406ddc.xml>

## **Appendix A: Example Images for Global Cooperation and Intelligence Leagues**

On the following pages are a series of example images along with a list of tokens that are present in each. Studying these should help you to better understand what we're looking for in the Global Cooperation and Intelligence Leagues.

Image 1: Arm, Deck, Layering



Image 2: Ripples, Horizon, Deck

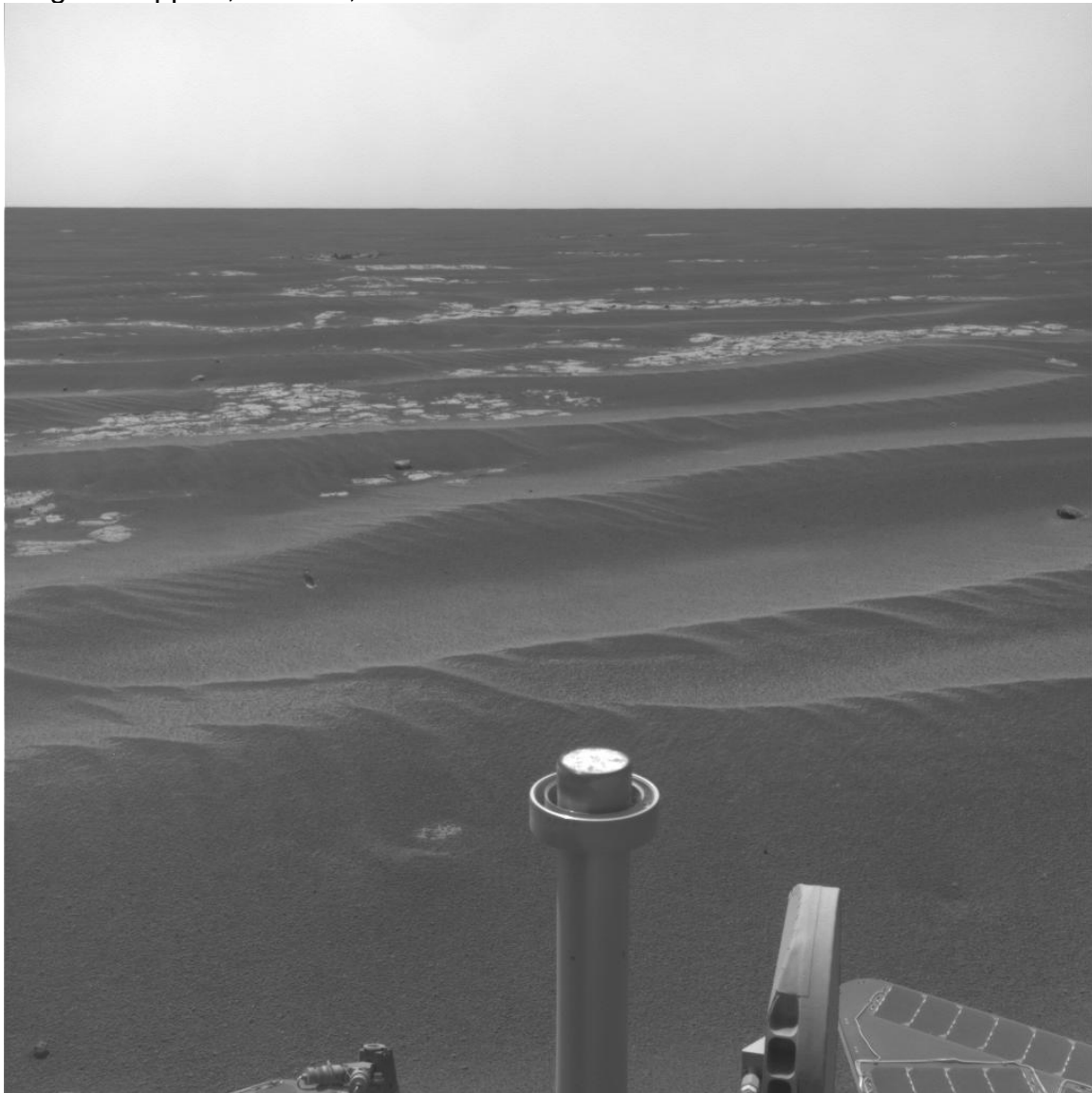


Image 3: Arm, Horizon, Shadows



Image 4: Ripples, Horizon

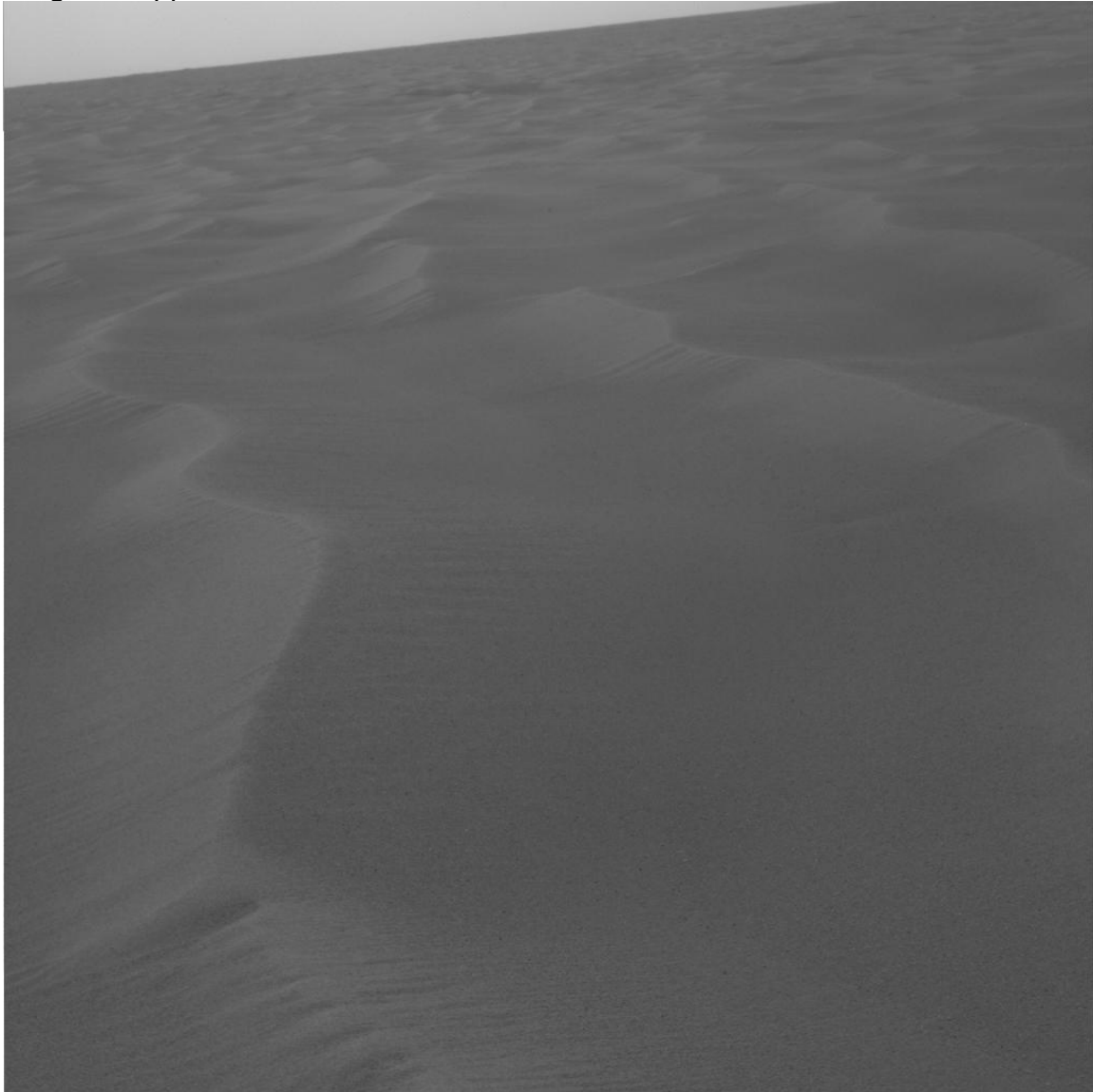


Image 5: Ripples, Horizon, Tracks, Layering



Image 6: Arm, Shadows



Image 7: Ripples , Tracks, Shadows

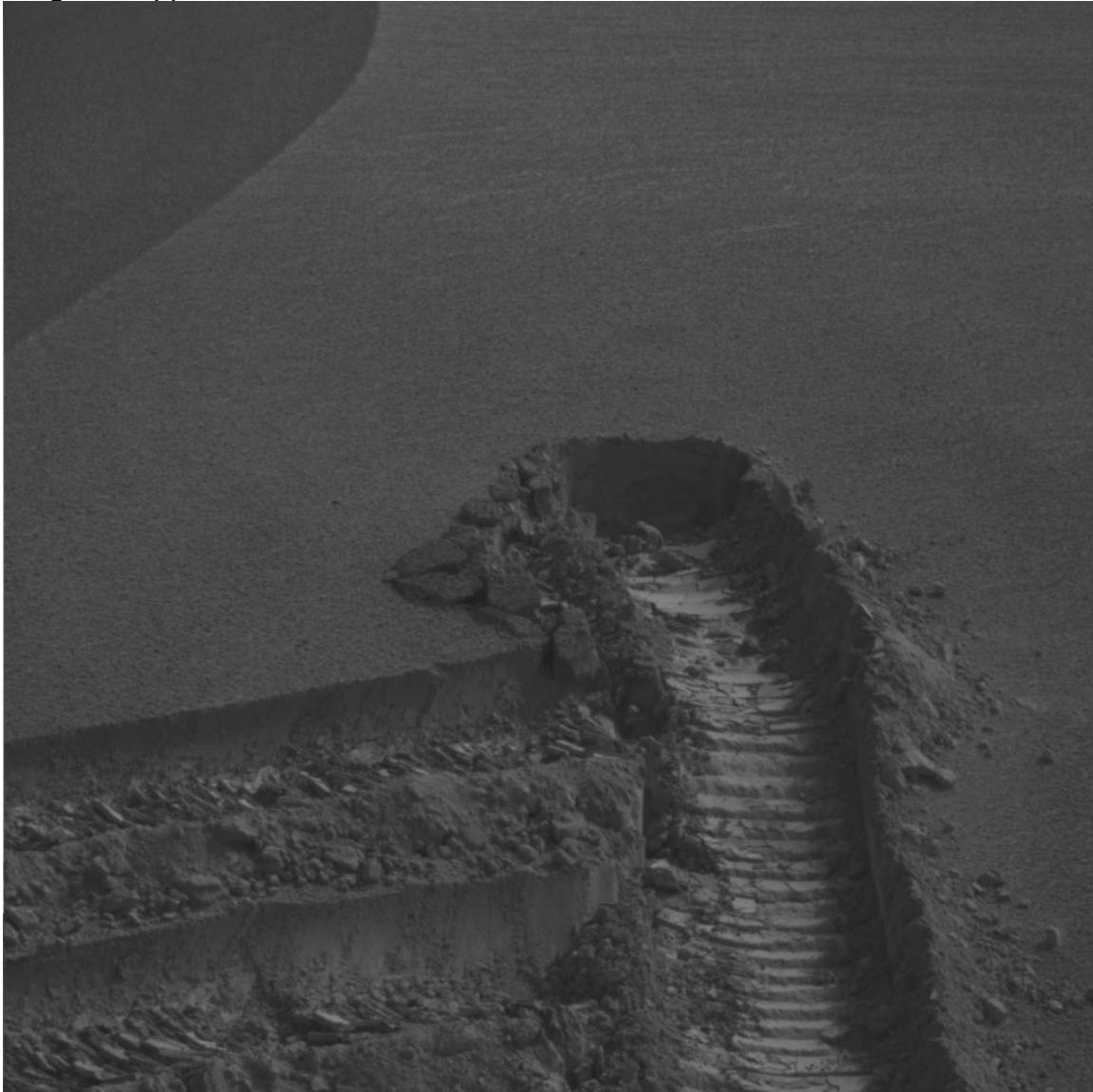


Image 8. All Sky



Image 9: Horizon, Shadow, Tracks



Image 10: Ripples , Tracks

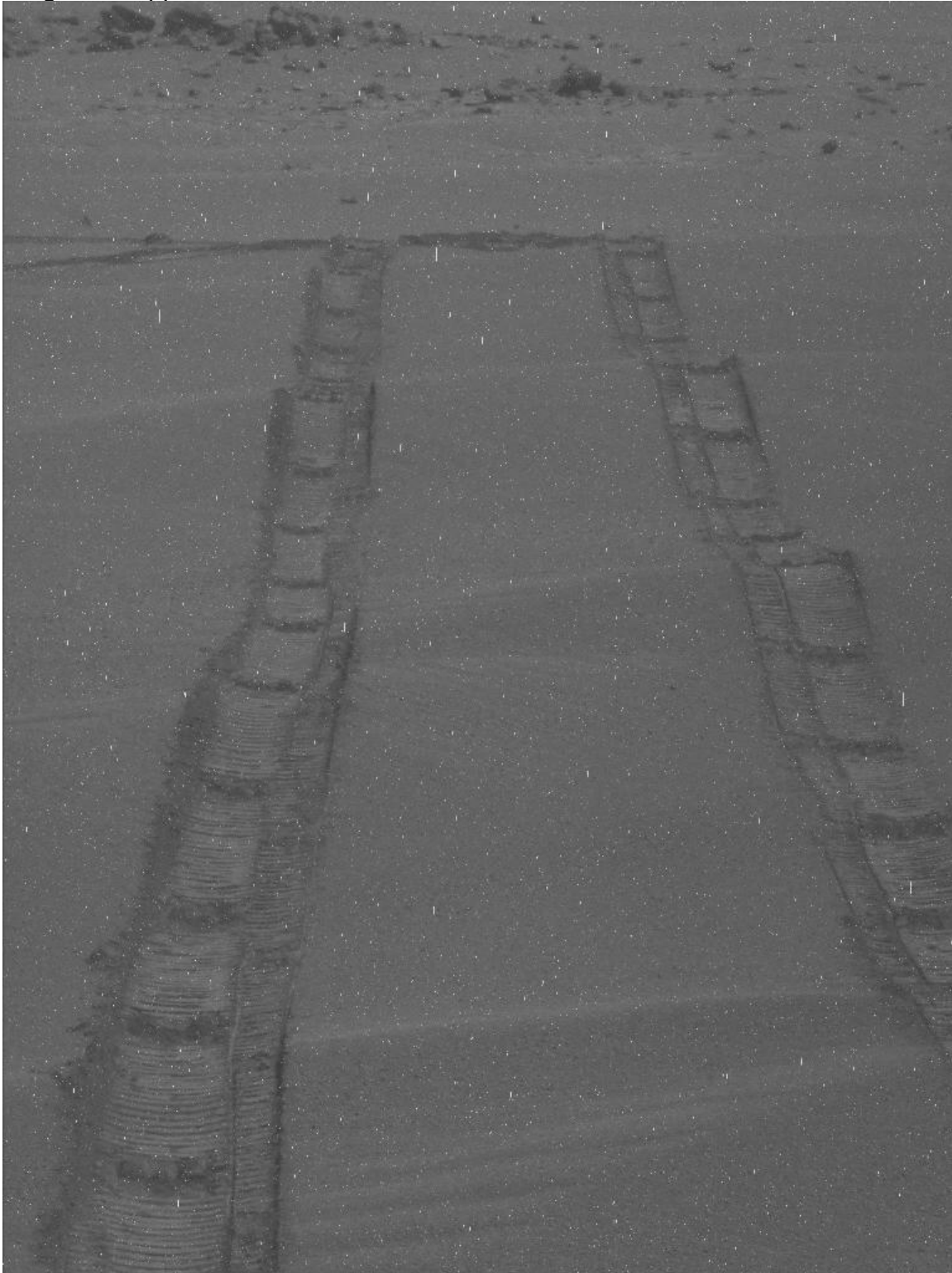


Image 11: Tracks



Image 12:, Ripples, Horizon, Deck, Tracks

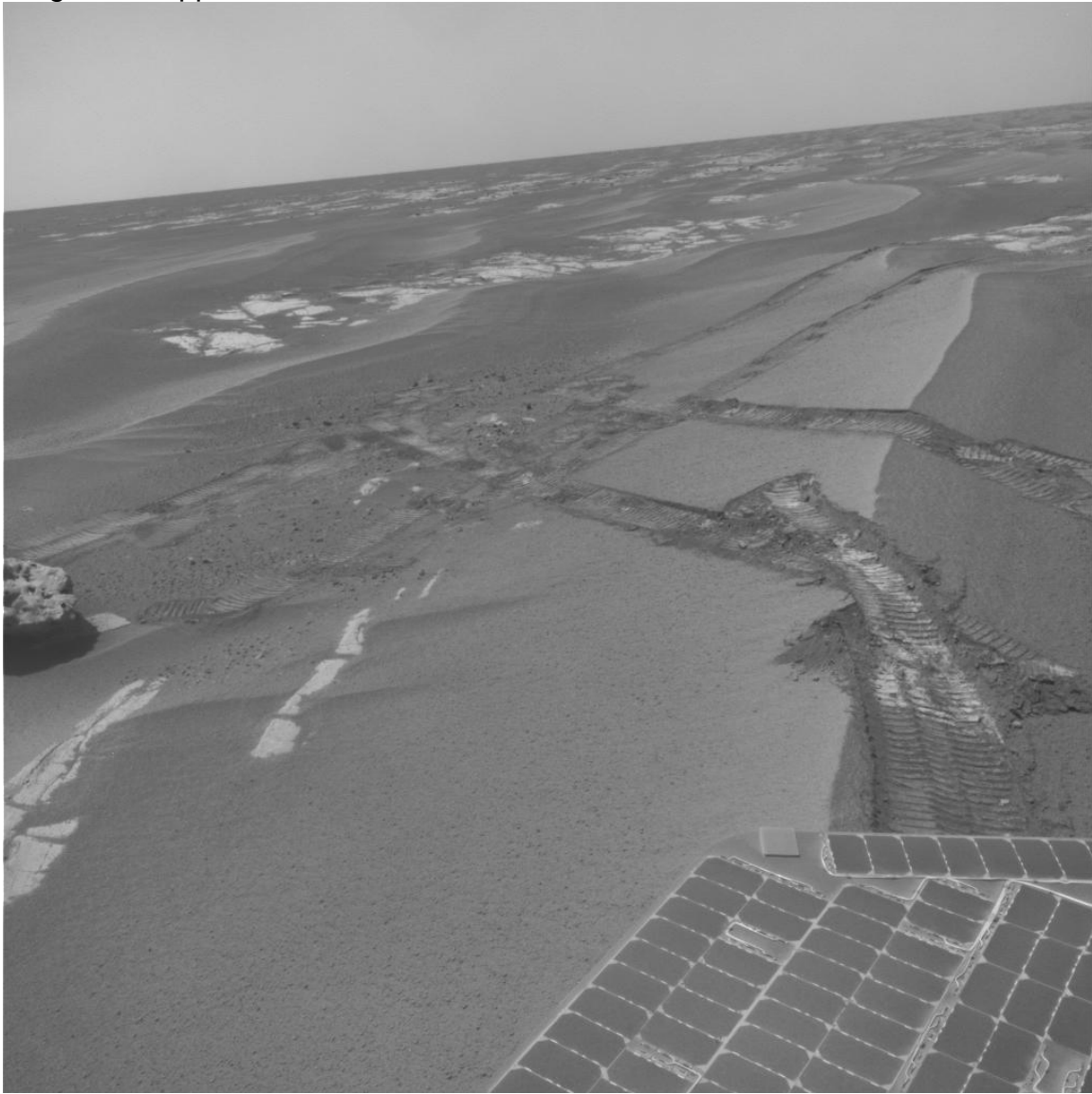


Image 13: Arm, Horizon, Shadow, Tracks



Image 14: Arm, Deck, Shadows, Tracks, Ripples

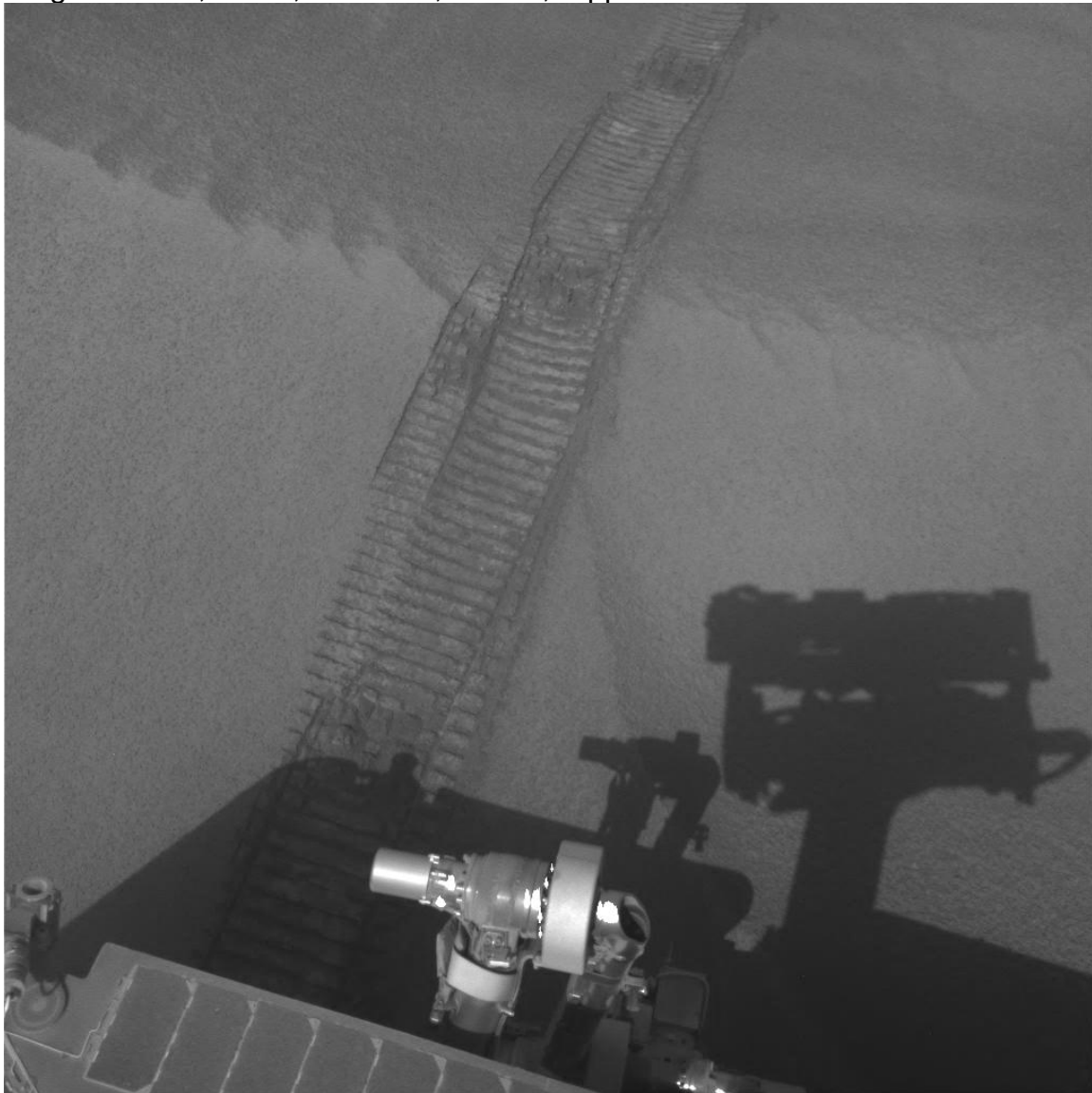


Image 15: Arm, Deck, Shadows, Tracks, Ripples, Layering

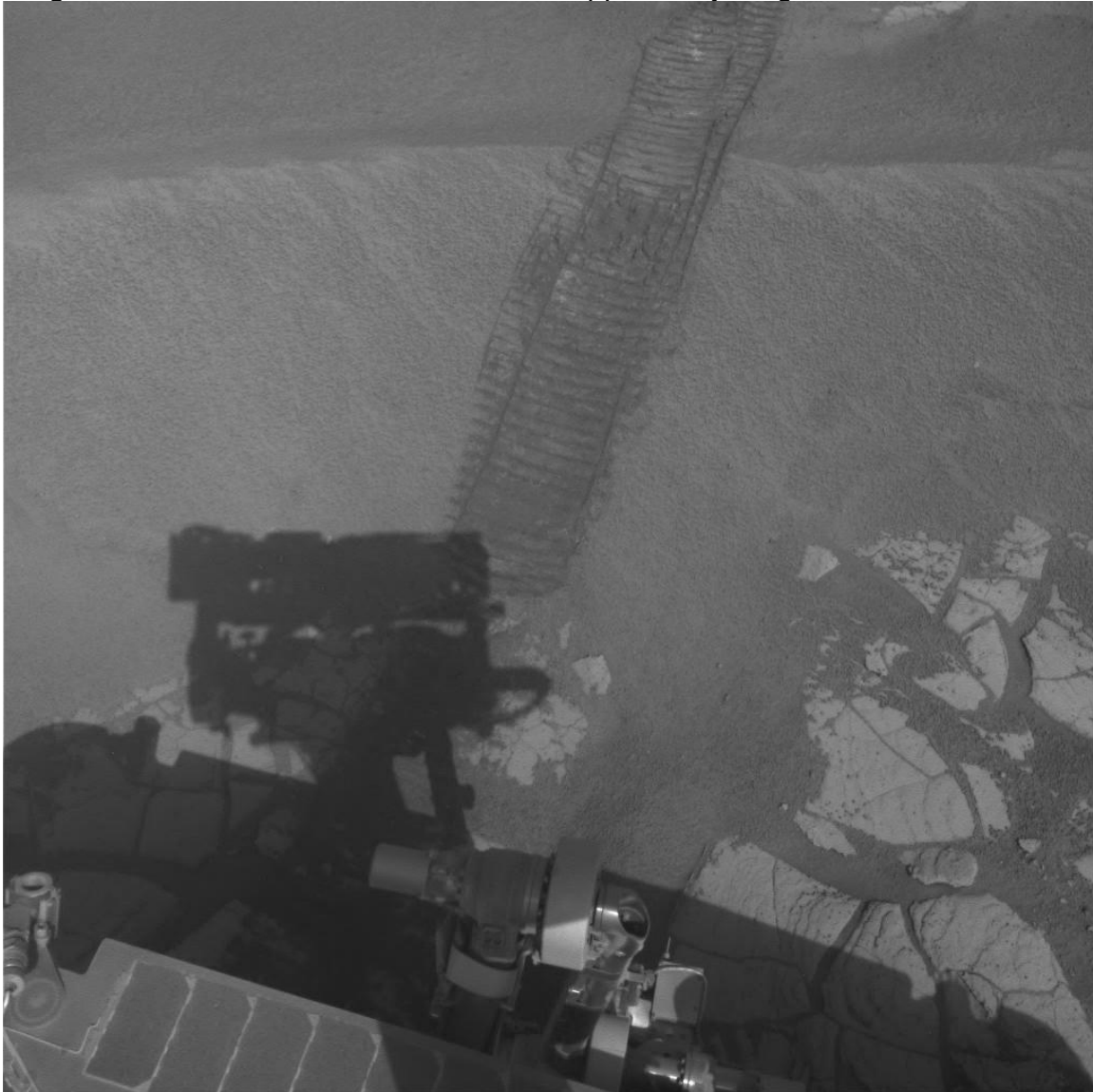


Image 16: Crater Rim, Horizon, Layering, Shadows



Image 17: Horizon, Layering, Tracks

